

## Online Appendix

Table 1A

### List of Variables and Data Sources.

Var.	Description (unit of measurement)	Source	Fr.
$S_t$	Number 2 soft red winter wheat price (USD cents per bushel of grain).	US Department of Agriculture (USDA)	D
	Number 2 yellow corn central Illinois price (USD cents per bushel of grain).		
	Number 1 yellow soybeans price (USD cents per bushel of grain).		
$F_t$	CBT no. 2 soft red winter wheat futures (USD cents per bushel of grain).	Thomson Reuters Datastream	D
	CBT corn futures (USD cents per bushel of grain).		
	CBT soybeans futures (USD cents per bushel of grain).		
$\gamma_t$	Corn, wheat, and soybean historical storage charges (USD per bushel of grain per day) – storage charges reported over the span of two consecutive delivery dates.	Prepared by CME Group Registrar	-
$\gamma_t(I_t)/\delta(I_t)$	Wheat Yearbook: soft red winter wheat beginning stocks, ending stocks, total use (million bushels).  Feed Grains Yearbook: corn beginning and ending stocks, total disappearance (million bushels).  Oil Crops Yearbook: Soybeans beginning stocks, ending stocks, total disappearance (million bushels).	USDA Yearbooks	Q
$\gamma_t(I_t)^\dagger/\delta(I_t)^\dagger$	World Agricultural Supply and Demand Estimates (WASDE). World Agricultural Outlook Board: USDA forecasts of U.S. beginning and ending stocks and disappearance of soft red winter wheat, corn and soybeans (million bushels).	USDA WASDE Report	M
$\rho_t$	Commercial traders long and short positions (open interest).	CFTC CIT CBT #2 soft red winter wheat, CBT corn, CBT soybeans	W
	Non-commercial traders long, short and spread positions (open interest).		
	Index traders long and short positions (open interest).		
	Total positions long and short (open interest).		

Note: Frequency (D) daily, (W) weekly, (M) monthly and (Q) quarterly;  $\gamma_t$  is available for the span between two consecutively maturing contract for each market. † Inventory data for robustness checks presented in Table 4A.

Table 2A

Unit Root Test Results.

	Wheat		Corn		Soybeans	
	$x_t$	$\Delta x_t$	$x_t$	$\Delta x_t$	$x_t$	$\Delta x_t$
$B$	-3.123** (0.0316)	-8.570*** (0.0000)	-3.804*** (0.0054)	-9.774*** (0.0000)	-3.703*** (0.0061)	-14.01*** (0.0000)
$y_t$	-3.445** (0.0142)†	-5.798*** (0.0000)†	-8.615*** (0.0000)†	-9.529*** (0.0000)†	-4.966*** (0.0001)	-8.041*** (0.0000)
$y_t^\ddagger$	-2.132 (0.2336)†	-6.873*** (0.0000)†	-3.358** (0.0177)†	-7.904*** (0.0000)†	-2.270 (0.1845)	-7.022*** (0.0000)
$y_{su}$	-2.961** (0.0470)	-5.585*** (0.0000)	-4.497*** (0.0007)†	-5.535*** (0.0000)†	-3.630*** (0.0075)	-5.363*** (0.0000)
$\rho_{nl,index}$	-1.399 (0.5748)	-8.360*** (0.0000)	-2.641* (0.0921)†	-6.147*** (0.0000)†	-3.222* (0.0889)	-8.062*** (0.0000)
$\rho_{nl,com}$	0.724 (0.9913)	-9.193*** (0.0000)	-2.770* (0.0703)†	-7.554*** (0.0000)†	-0.377 (0.9060)	-8.412*** (0.0000)
$\rho_{w,com}$	-3.007** (0.0421)	-9.617*** (0.0000)	-3.564** (0.0104)	-8.853*** (0.0000)	-3.653*** (0.0070)	-9.441*** (0.0000)
$\rho_{w,index}$	0.430 (0.9820)	-8.616*** (0.0000)†	-2.039 (0.2699)	-5.849*** (0.0000)	-0.973 (0.9397)	-10.09*** (0.0000)
$\rho_{w,ncom}$	-0.812 (0.8062)	-11.13*** (0.0000)†	-5.507*** (0.0002)	-9.611*** (0.0000)	-5.262*** (0.0003)	-10.37*** (0.0000)

Notes: Augmented Dickey-Fuller (ADF) test with  $H_0$ : Series has a unit root. \*, \*\*, \*\*\* indicate rejection of  $H_0$  at 10 per cent, 5 per cent and 1 per cent significance level respectively. † Phillips-Perron used instead of ADF due to heteroscedasticity in the residuals of the test regression,  $H_0$ : Series has a unit root. Lag length determined by Modified Akaike Information Criterion following Ng and Perron (2001). Maximum lag length is 20.  $\gamma$  is excluded due to insufficient variation. MacKinnon (1996) one-sided p-values in (.). ‡ USDA WASDE inventory data. Data spans over the period March 2006 to July 2015 for wheat and corn and January 2006 to September 2015 for soybeans.

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Table 3A

Regression Estimation Results Eq. (10) with a. Alternative Risk Premium Indicators and  
b. Reverse Causality Estimates.

	a. Alternative $\rho$ (net-long)				b. Reverse Causality		
	Wheat	Corn	Soybeans		Wheat	Corn	Soybeans
$c$	-3.321*** (-3.89)	1.848*** (5.92)	2.981*** (5.05)	$\beta_B$	0.029 (0.22)	-1.724 (-1.53)	-0.484 (-0.48)
$\beta_Y$	0.053*** (3.44)	0.120*** (3.09)	0.184*** (5.63)	$\beta_Y$	0.036* (1.73)	1.702*** (5.97)	1.992** (2.50)
$\beta_{y_I}$	1.376*** (4.06)	-0.284*** (-3.60)	-0.280*** (-3.52)	$\beta_{y_I}$	-0.588 (-1.63)	-0.069 (-0.14)	1.255 (1.41)
$\beta_{y_{I2}}$	-0.134*** (-3.97)	0.018*** (3.63)	0.011*** (3.59)	$\beta_{y_{I2}}$	0.056 (1.60)	0.004 (0.13)	-0.048 (-1.42)
$\beta_{y_{su}}$	-0.011 (-0.51)	0.012** (2.16)	0.013** (2.45)	$\beta_{y_{su}}$	0.029 (0.98)	0.022 (0.82)	-0.025 (-0.44)
$\beta_{\rho_{nl,com}}$	0.007 (0.46)	0.003 (1.10)	0.003 (1.42)	$\beta_{\rho_{w,com}}$	-1.057*** (-15.0)	-0.918*** (-5.19)	-1.783*** (-5.65)
$\beta_{\rho_{nl,ind}}$	-0.121* (-1.08)	-0.026*** (-3.54)	-0.005 (-1.29)	$\beta_{\rho_{w,ncom}}$	-1.722*** (-12.3)	-1.210*** (-6.46)	-1.090*** (-4.79)
Diagnostics							
R <sup>2</sup>	0.423	0.569	0.495		0.936	0.838	0.674
AR	6.473***	1.999	0.578		8.487***	5.705***	41.41***
Norm.	11.73***	0.382	17.96***		0.356	5.909	0.022
Heter.	2.459*	0.785	2.133**		0.474	0.830	1.880
Hans.	1.518	1.130	2.420**		2.679**	2.488**	5.307***

Notes: Newey and West (1987) robust standard errors used for t-statistics in (.). \*, \*\*, \*\*\* indicate 10 per cent, 5 per cent, and 1 per cent significance level, respectively. 'R<sup>2</sup>' is the R-square of the regression; 'AR' is a test for first and second

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order autocorrelation in the residuals; 'Norm.' is a test for normality of residuals; and 'Heter.' is a test for heteroscedasticity in the residuals; 'Hans.' is the Hansen (1992) test for parameter stability.

Table 4A

Regression Estimation Results Eq. (10) Model I with a. USDA Predicted Monthly Inventory Data and b. USDA Quarterly Observed Inventory Data.

	a. Predicted Monthly				b. Quarterly Observed		
	Wheat	Corn	Soybeans		Wheat	Corn	Soybeans
$c$	0.176 (0.30)	2.465*** (4.87)	2.222*** (3.66)	$c$	-1.876** (-2.22)	2.321*** (5.57)	3.107*** (5.89)
$\beta_Y$	0.047** (2.40)	0.207*** (4.73)	0.259*** (4.31)	$\beta_Y$	0.053*** (2.98)	0.182*** (3.22)	0.167*** (2.94)
$\beta_{y_I}$	-0.034 (-0.13)	-0.346** (-2.19)	-0.192* (-1.87)	$\beta_{y_I}$	0.802** (2.39)	-0.303*** (-3.64)	-0.306*** (-3.58)
$\beta_{y_{I2}}$	0.005 (0.17)	0.024** (2.15)	0.017* (1.87)	$\beta_{y_{I2}}$	-0.077** (-2.29)	0.019*** (3.64)	0.011*** (3.57)
$\beta_{y_{su}}$	0.017 (0.84)	-0.005 (-1.45)	0.002 (0.55)	$\beta_{y_{su}}$	0.027 (1.02)	0.010** (2.18)	0.015*** (3.09)
$\beta_{\rho_{w,com}}$	0.128** (2.43)	-0.009 (-0.31)	0.034 (1.16)	$\beta_{\rho_{w,com}}$	0.087 (1.61)	0.011 (0.46)	0.007 (0.23)
$\beta_{\rho_{w,ind}}$	-0.207*** (-3.94)	-0.039** (-2.38)	0.005 (0.45)	$\beta_{\rho_{w,ind}}$	-0.148** (-2.65)	-0.037** (-2.18)	-0.001 (-0.12)
Diagnostics							
R <sup>2</sup>	0.430	0.478	0.416		0.541	0.551	0.612
AR	1.583	0.599	0.077		1.609	2.547	0.153
Norm.	12.15***	8.886**	22.95***		11.47***	1.224	36.66***
Heter.	1.797	0.587	0.783		1.637	2.061	1.256
Hans.	1.991	1.383	2.664**		1.232	1.760	1.522

Notes: Newey and West (1987) robust standard errors used for t-statistics in (.). \*, \*\*, \*\*\* indicate 10 per cent, 5 per cent, and 1 per cent significance level, respectively. 'R<sup>2</sup>' is the R-square of the regression; 'AR' is a test for first and second

order autocorrelation in the residuals; ‘Norm.’ is a test for normality of residuals; and ‘Heter.’ is a test for heteroscedasticity in the residuals; ‘Hans.’ is the Hansen (1992) test for parameter stability.

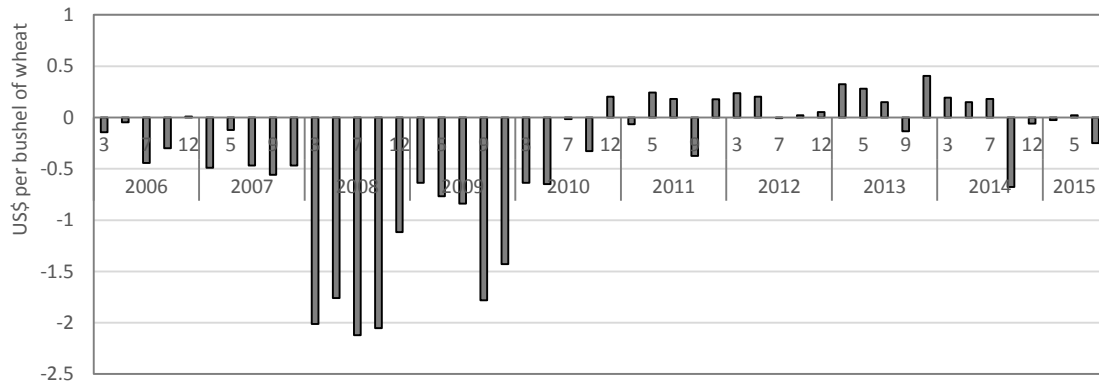
Table 5A

Markov switching regression estimation results eq. (11), carry variables and diagnostics.

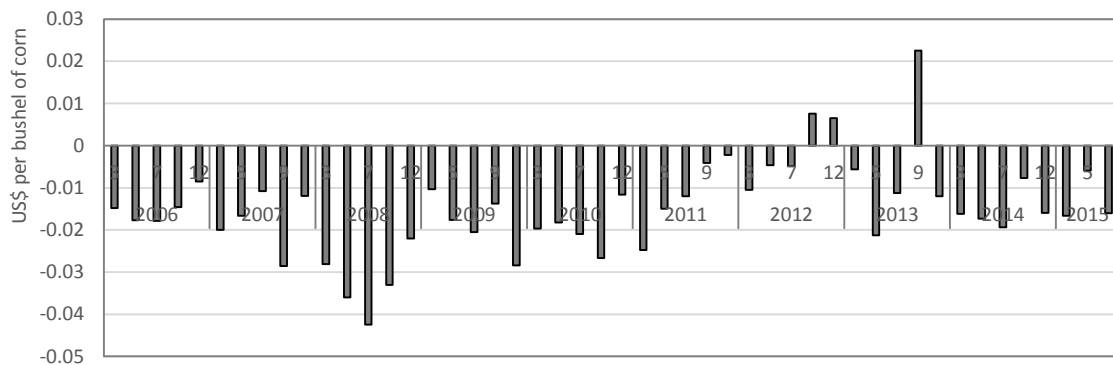
	CBT Wheat		CBT Corn		CBT Soybeans	
	I	II	I	II	I	II
	$i = com$	$i = ncom$	$i = com$	$i = ncom$	$i = com$	$i = ncom$
Common						
$\beta_y$	0.036*** (3.4690)	0.038*** (3.4498)	0.133*** (8.3827)	0.142*** (9.5635)	0.132*** (9.8549)	0.169*** (16.207)
$\beta_{y_1}$	0.686*** (8.0773)	1.273*** (21.868)	-0.180*** (-14.432)	-0.184*** (-16.043)	-0.295*** (-83.791)	-0.343*** (-209.65)
$\beta_{y_{12}}$	-0.066*** (-8.0930)	-0.120*** (-20.497)	0.011*** (14.352)	0.012*** (15.917)	0.011*** (74.186)	0.013*** (151.60)
$\beta_{y_{su}}$	0.018 (1.2566)	0.016 (1.1325)	0.004 (1.3543)	0.004 (1.4342)	0.011*** (4.3058)	0.011*** (4.3703)
Diagnostics						
Sig	-3.803*** (-30.171)	-3.758*** (-29.632)	-5.139*** (-42.224)	-5.123*** (-41.863)	-4.955*** (-50.616)	-5.032*** (-50.449)
Likl	103.9633	101.4497	171.3206	170.6313	222.4686	224.4162
SSR	0.054302	0.067757	0.002495	0.002416	0.012255	0.013729
DW	1.697198	1.676145	2.591485	2.609091	1.945598	1.909893

Notes: HAC standard errors are used. (.) z-statistic. \*, \*\*, \*\*\* indicate 10 percent, 5 percent and 1 percent significance level, respectively. “Sig” is log of sigma. “Likl” is log likelihood. “SSR” is sum of squared residuals. “DW” is the Durbin–Watson

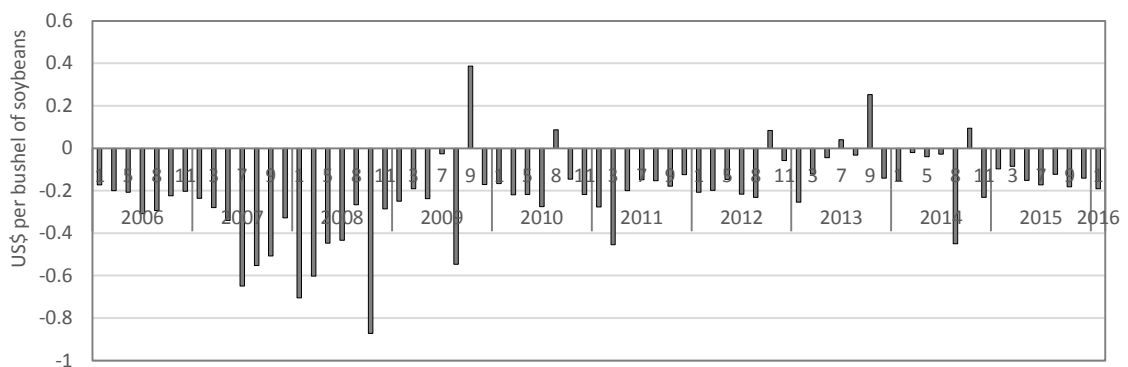
(a) CBT Wheat



(b) CBT Corn



(c) CBT Soybeans



*Note:* The bars indicate the basis at maturity, that is, the difference between the cash price and the respective futures price at each contract’s maturity. The average of the last trading week of each contract is taken for both futures and cash prices.

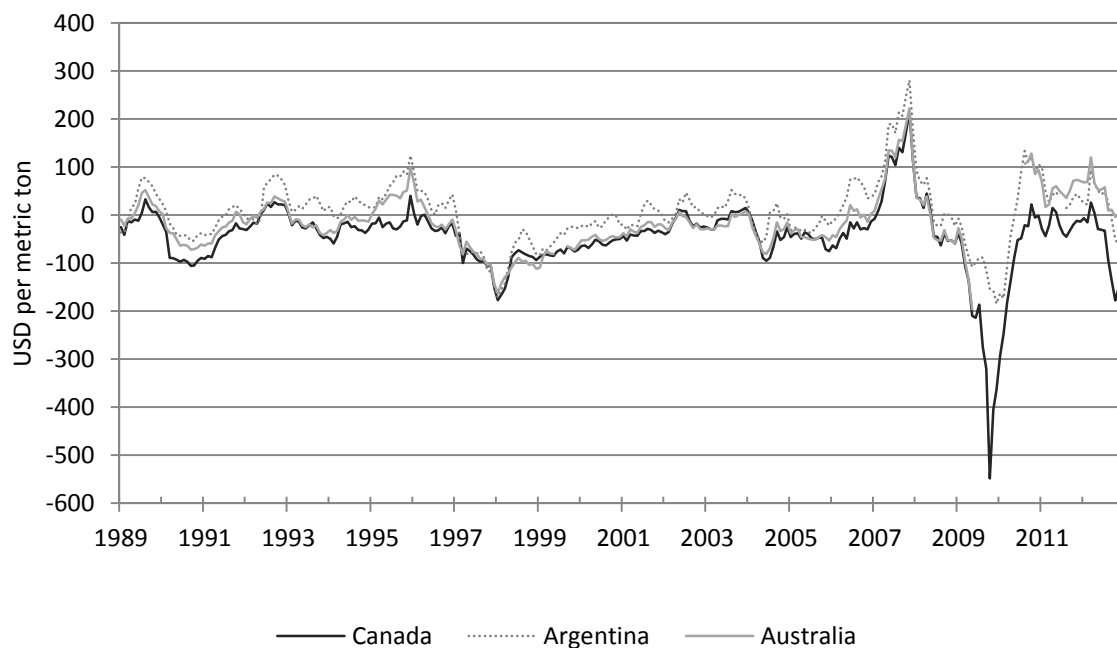
*Source:* Own calculation based on Datastream and USDA data.



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Fig. 1A. Non-Convergence in US Grain Markets, Jan. 2006 – Jan. 2016.



*Note:* After the introduction of the VSR, US soft red winter wheat prices increased rapidly relative to Canadian, Argentinian, and Australian prices. The extent to which price changes occurred in the physical market was even more surprising, as US wheat was previously cheaper than elsewhere, due to an exceptionally good harvest.

*Source:* USDA.

Fig. 2A. US Soft Red Winter Wheat Cash Prices Less Prices in Canada, Argentina and Australia (monthly, May 1989–Apr 2013).